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Detection and Identification of Weak Seismic Events Using SVD Beamforming

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Detection and identification of low magnitude or weak seismic events are still among the most difficult tasks in the monitoring of a Comprehensive Test Ban Treaty. Seismic arrays have proven to be quite important for event location and identification as they provide information such as phase velocity and bearing estimates, in addition to the array gain for improved SNR. However due to low signal coherence at the higher frequencies, array gain provided by conventional beamforming is often insufficient for high-confidence monitoring. We have developed an efficient time-domain beamforming algorithm based on the singular value decomposition (SVD) technique. The SVD is a natural way to split array data space into dominant (signal) and subdominant (noise) subspaces. In our approach, the array data is formed into a measurement matrix, the columns corresponding to the spatial channels and rows the seismic time history. After shifting the columns of the measurement matrix using an appropriate set of time-delays, the SVD is used to decompose the signal and noise subspaces. The measurement matrix is then replaced by a low-rank signal matrix that is used to form a high gain beam. The method is applied to a large set of seismic events from the MENA region and the results are compared with conventional beamforming techniques.

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